

Climate Conversations - Energy Futures

A “Net Energy” lens perspective for Engineering NZ.

Nathan Surendran - Transition Engineer

[About / Contact Me](#)

This presentation available at bit.ly/NS_CCEF

Introduction:

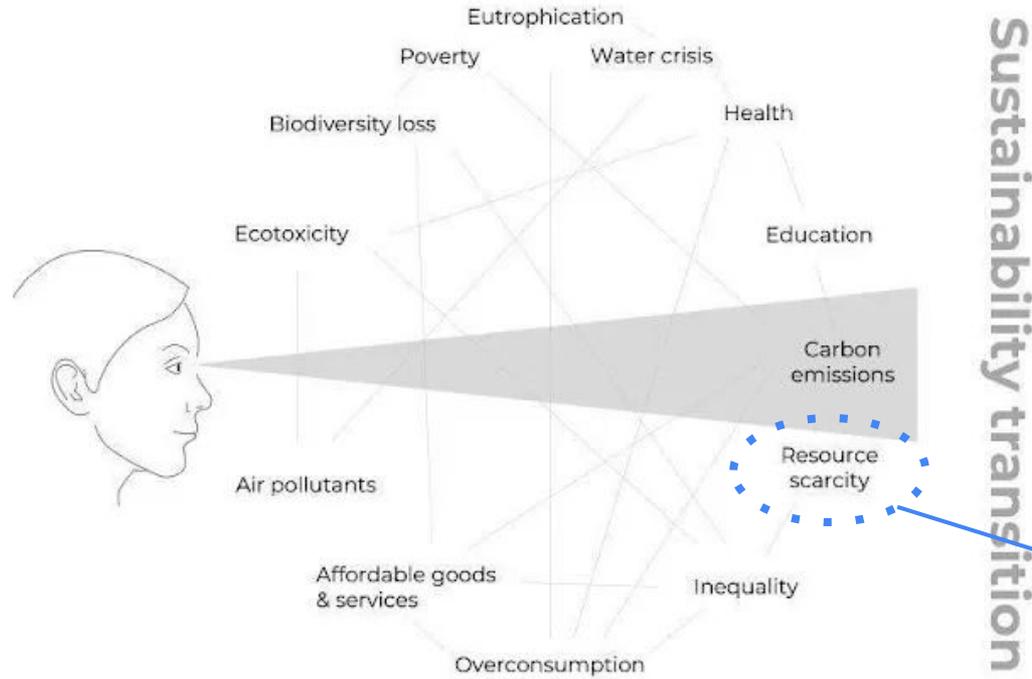
- Chartered Engineer 2009 Building Services through CIBSE.
- Professional energy expertise. Building physics, energy flows.
- Broadened my scope to include global energy supply systems and trends.
- Hands on - have built my own off grid, passive solar, low energy home in Clifton, Invercargill over the last few years.
- Engaged and committed to educating society about energy.
- Trying to make a positive difference.

This presentation:

Engineering needs to shift our perspective to overcome our blind spots, particularly with respect to energy!

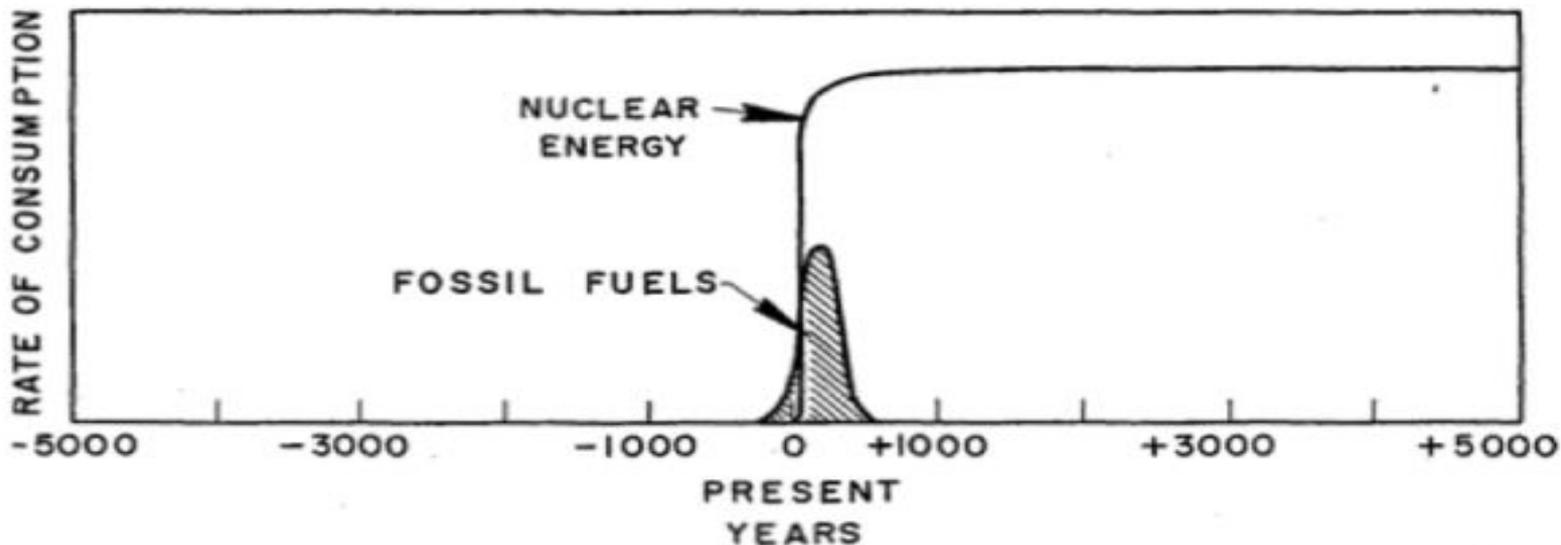
- We need to understand:
 - A broad perspective on the polycrisis.
 - How vulnerable we are in NZ!
 - How fundamental oil is to our industrial economy.
 - How much work our 'energy slaves' do for us.
 - How quickly the 'net energy' from oil supply is changing globally.
- Mainstream economic analysis is fundamentally blind to this perspective.
- Our strategic futures are being based on this energy blind economics.
- What are the implications of this perspective for Transportation in Aotearoa?

Climate conversations can't ignore the polycrisis!



We need to take a closer look at this issue, especially related to oil supply!

Taking the long view.



Source: M. King Hubbert, "Nuclear Energy and the Fossil Fuels," 1956, available at <http://www.hubbertpeak.com/hubbert/1956/1956.pdf>

The main facts around which my presentation today is formed:

Underlying all economic activity, is energy expenditure.

Fossil fuel energy, particularly oil, and specifically diesel, is the ‘lifeblood’ of industrial society.

This is a non-renewable, depleting resource.

*It’s extraction and use is subject to **diminishing returns**.*

[Reality 101 - Energy & Economy - 1:45 course on Energy in the Economy by Nate Hagens](#)

[Peak Oil is Here! World oil production peaked in 2018](#)

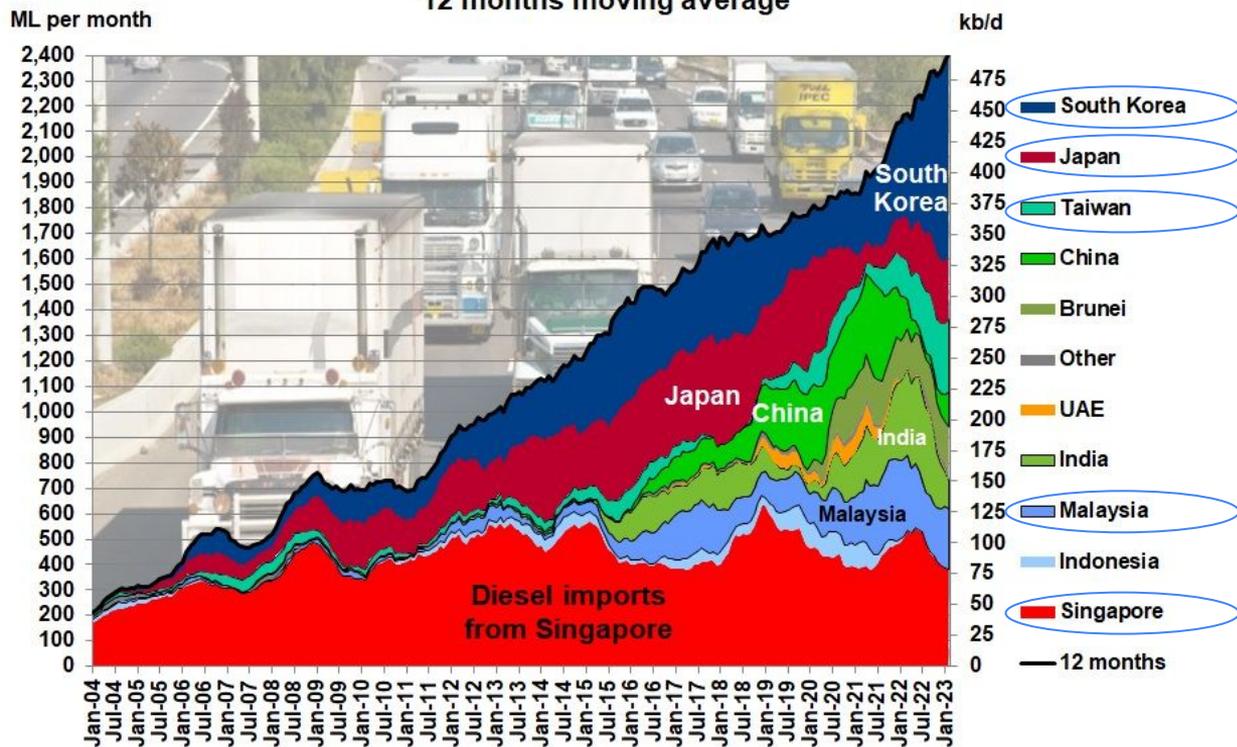
[Arthur Berman “Oil: It was the best of fuels, it was the worst of fuels” | The Great Simplification](#)

[\(Will civilization collapse because it’s running out of oil? By Richard Heinberg](#)

[The Status of Global Oil Production \(Part 1\) By Roger Blanchard\)](#)

Our situation isn't very different to Aussie

Australian diesel imports by country Jan 2004 - Feb 2023
12 months moving average

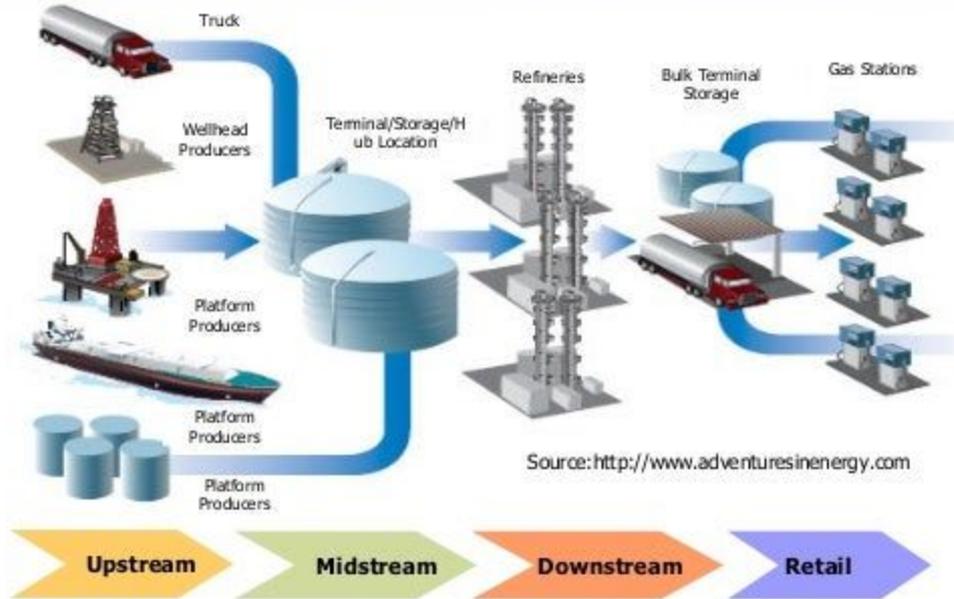


Over 80%
from South
China Sea
exposed
sources...

Source of data: Australian Petroleum Statistics, Table 4A

NZ is more vulnerable, post Marsden Point.

Picture below gives an overview of the supply chain of the oil and gas industry. Industry is organized into three broad categories based on the activities performed therein. They are mainly a) Upstream (Finding & producing hydrocarbons) b) Downstream (Refining hydrocarbons and producing saleable petroleum byproducts) c) Retail (Selling the byproducts to all the users who need them). Midstream, though is not a very popular term is used to describe the transport part.



The head of the Northern Australia Strategic Policy Centre Dr John Coyne is aghast at the closure of Marsden Point:

"They're very naive," he said.

"They're buying into a very dated view of globalisation, and they certainly haven't learned the lessons from COVID-19, around secure supply chains and national resilience."

Wax for
170
birthday candles or
27
crayons.



Lubricants to make about
one quart
of motor oil.



About
four pounds
of charcoal briquettes.



Gasoline to drive a medium-sized car
(17 miles per gallon) for more than
280 miles



Distillate fuel to drive a large truck
(five miles per gallon) for almost

40 miles

If jet fuel fraction is included,
that same truck can run nearly

50 miles



Asphalt to make about

one gallon

of tar for patching roofs or streets.



Nearly

70 kilowatt-hours

of electricity at a power plant
generated by residual fuel.



Liquefied gases,
such as propane, to fill

12

small (14.1-ounce) cylinders for home,
camping or workshop use.



There would be enough petrochemicals left in that same barrel to also provide the base for:



Oil's outside contribution to our lives:

An average human working all day generates around 0.6kWh of useful energy output.

One barrel of oil contains about 1700 kWh of fossilised and geologically processed solar energy.

Therefore, one barrel of oil, contains about 10.5 years of human labour.

Energy slaves *are* our standard of living!

After conversion losses, we actually get around 4.5 years of useful energy as work done at the point of use.

That barrel of oil currently costs around \$100USD.

If we were to pay for that energy output as human labour, **each barrel of oil would be worth $4.5y \times \$50,000 \text{ NZD} = \$225,000 \text{ NZD}$**

The equivalent labour input is mind boggling!

We currently use around 100 million barrels of oil per day globally.

New Zealand uses around 130,000 barrels of oil per day.

That is, the oil energy used in NZ **does for us in one day**, $4.5\text{y/b} \times 130,000\text{b}$

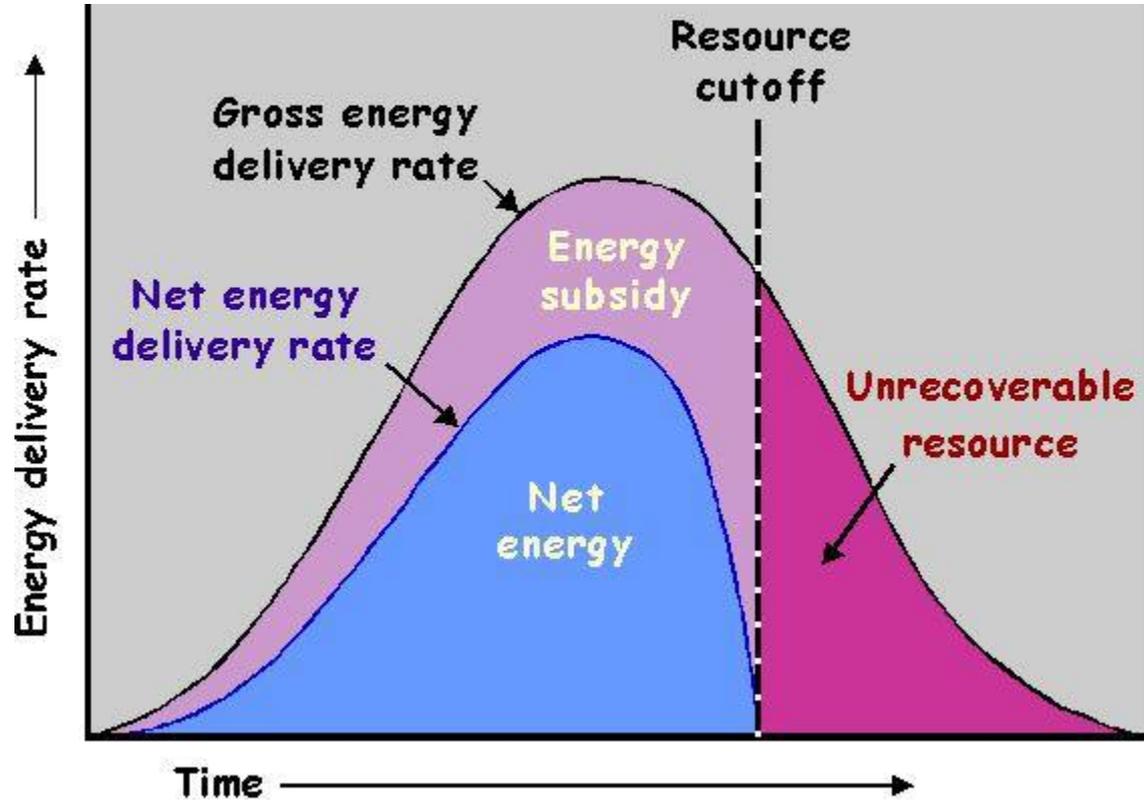
= **585,000 years of human labour equivalent work PER DAY!!!**

Energy Profit, net of the cost of production, is like fitness (Darwin):

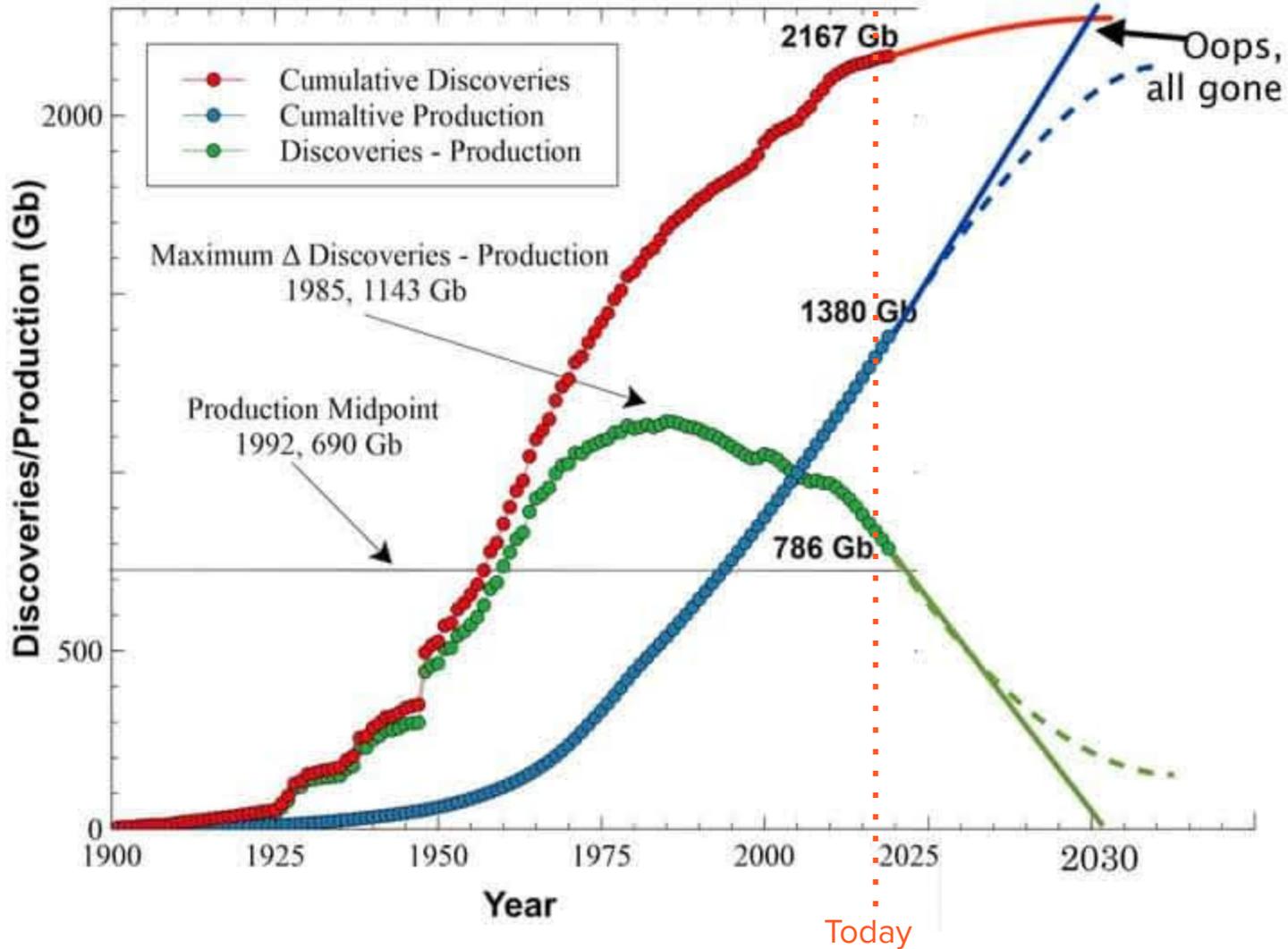


If the Cheetah expends more energy chasing prey, than it gets from eating the prey, it will eventually starve.

The rate of change of net energy is exponential, due to annual percentage decreases.

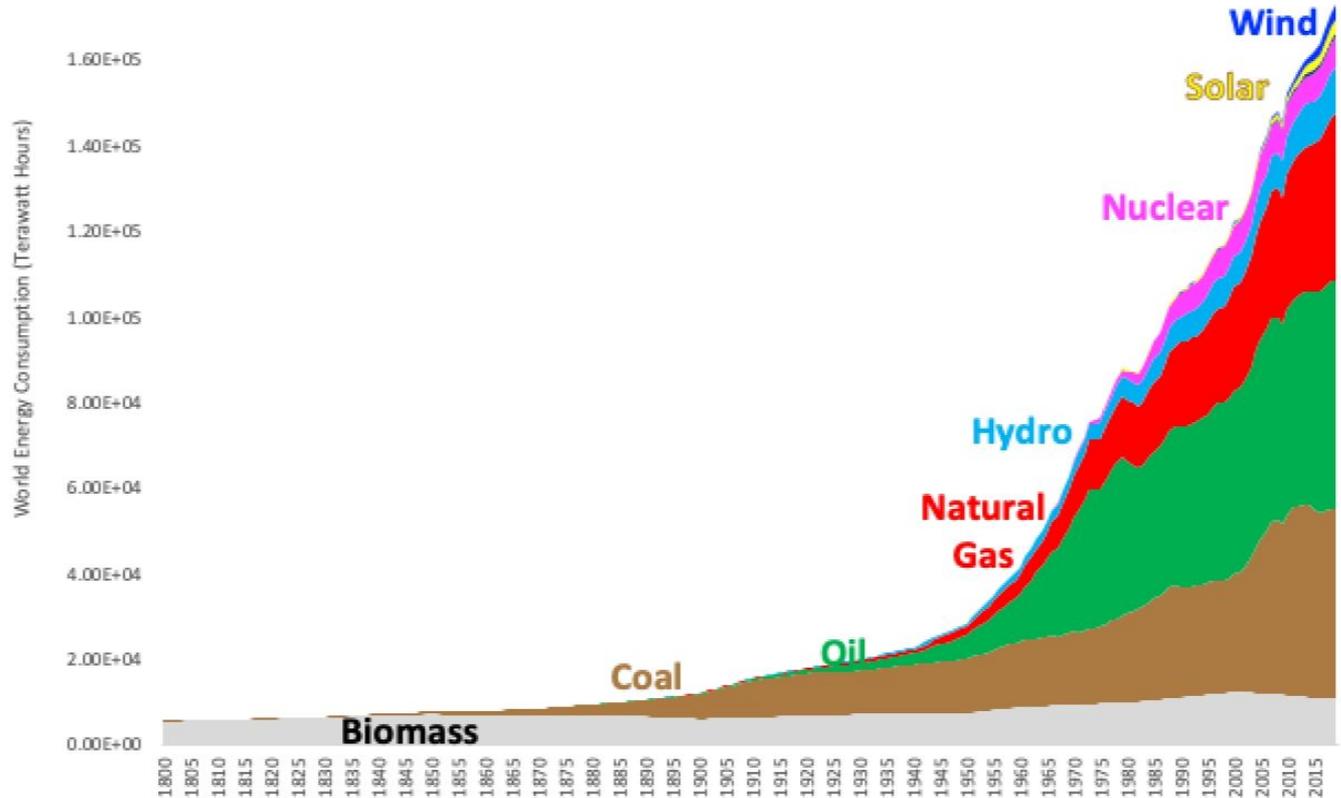


Global Oil Discoveries and Production



The reality of our current 'energy transition'

Energy transitions are additive
The relative percent of fuels changes but volumes rarely decrease
The world uses as much biomass today as in 1800



Source: EIA, BP, IEA, FRED, OWWD, World Bank & Labyrinth Consulting Services, Inc
Labyrinth/Climate Change/OWID/ OWID PRIMARY ENERGY CONSUMPTION_global energy substitution

Expected growth in oil consumption?

3.5% per annum
global growth
average
historically since
we started using
oil in the 1920's.



The last 20 years
we've consumed
the same amount
as the previous
80 years...

The amount of oil
we'd consume in the
next 20 years at the
same growth rate, is
the rest of the
proven resource!

Mainstream Economics is energy blind...



**“LABOR WITHOUT ENERGY IS A CORPSE”
“CAPITAL WITHOUT ENERGY IS A SCULPTURE.”**

ECONOMIST STEVE KEEN: [BIT.LY/2QG34FG](https://bit.ly/2QG34FG)

Can't satisfy both producers & consumers



Globally, marginal cost of new production is now, on average, close to \$100/barrel

Mainstream Economic analysis is failing us!

To be useful, it must incorporate the biophysical reality I'm pointing to.

It currently hasn't.

Specifically:

1. Mainstream economics is fundamentally energy blind.
2. Energy's contribution to economic output is hugely underestimated.
3. There's a bunch of erroneous underlying assumptions in CBA models that should be interrogated and challenged.

Economic Dogmas:

(The links are to critiques of the stated assumptions, to help understanding of the flawed logic.)

- Climate change effects on economic output are minimal. bit.ly/3JsKxUq
- The ‘invisible hand’ of the market will provide. bit.ly/3d4EkSJ
- Substitutability of resources means that we can expect a [new energy source](#) to be available to replace fossil fuels. e.g. hydrogen (which is commonly seen as a source, but is a carrier like a battery). bit.ly/hhype
- **Decoupling economic activity from energy use and emissions intensity is possible.** bit.ly/3UojG0r bit.ly/2jeJclW
- **Technological progress will overcome biophysical limitations, and costs will continue to reduce.** bit.ly/SEE_Summ

Our Renewable Future?

Build out of renewables at the scale that supports BAU is implausible. Why?

- The economy already is maxed out in energy supply terms. Where does the energy (diesel) that **needs to be invested** to build the renewables come from?
- The build out requires resources at a global scale that **simply aren't there**. If NZ did it and others fail to, what are we going to use all this energy for?
- The renewable energy systems proposed have a design life of 25-30 years. Even if we could do it once, can we do it twice?
- We should, from an ethical perspective, leave some resources in the ground so that future generations have the agency to make their own decisions on its use?

Transition to 100% renewable energy? Sure.

Maintain current levels of growth and consumption? Not gonna happen.

Where does this leave us?



Exercise

Cross your arms

Discussion

Takeaways, in summary...

I'm aware that discussion of a 'peak oil' reduction in supply rates isn't fashionable.

I'm simply reporting the reality of the oil supply situation globally, as it stands.

There are many additional factors, which I'm not discounting the significance of.

I hope you'll check out my extensive references and ask me further questions.

I know it's hard to hear this message, but it'll be harder for all if it's ignored.

I know that regardless of exact timing, it's better to be ahead of the curve.

I think this must include consideration of proactive [degrowth](#) policies and actions.

I believe that we need to have this type of conversation far more often.

I want to help, but beyond educating around this subject, I'm open to your ideas!

**Further
resources:**

A single article that sums up our predicament?

Short Summary: https://bit.ly/SEE_Summ Longer Summary: <https://bit.ly/aedbiphec>

Presentation (40 minutes): <https://www.youtube.com/watch?v=CTGCDtoPrqY>

Blogs to read that are telling this story from various angles:

- <https://www.thegreatsimplication.com/>
- <https://dothemath.ucsd.edu/>
- <https://surplusenergyeconomics.wordpress.com/>
- <https://www.patreon.com/ProfSteveKeen>
- <https://consciousnessofsheep.co.uk/>
- <https://ourfiniteworld.com/>
- <https://beyondthisbriefanomaly.org/>
- <https://erikmichaels.substack.com/>

If you're more into listening, a podcast suggestion:

[Nate Hagens](#) is an educator, systems thinker, partner and alliance builder for the future of a living Earth and human culture. He has started a podcast around his understanding of what we've covered today, which he calls "[The Great Simplification](#)".

His '[Super Organism](#)' paper, [summarised in this animation](#), explains the emergent properties of complex systems, in the context of human society, as they exist today. You can't extrapolate from the individual to society. Yet this is a fundamental assumption of mainstream economics.

Here's an [interview with Nate](#) that gives a good overview of his perspective.

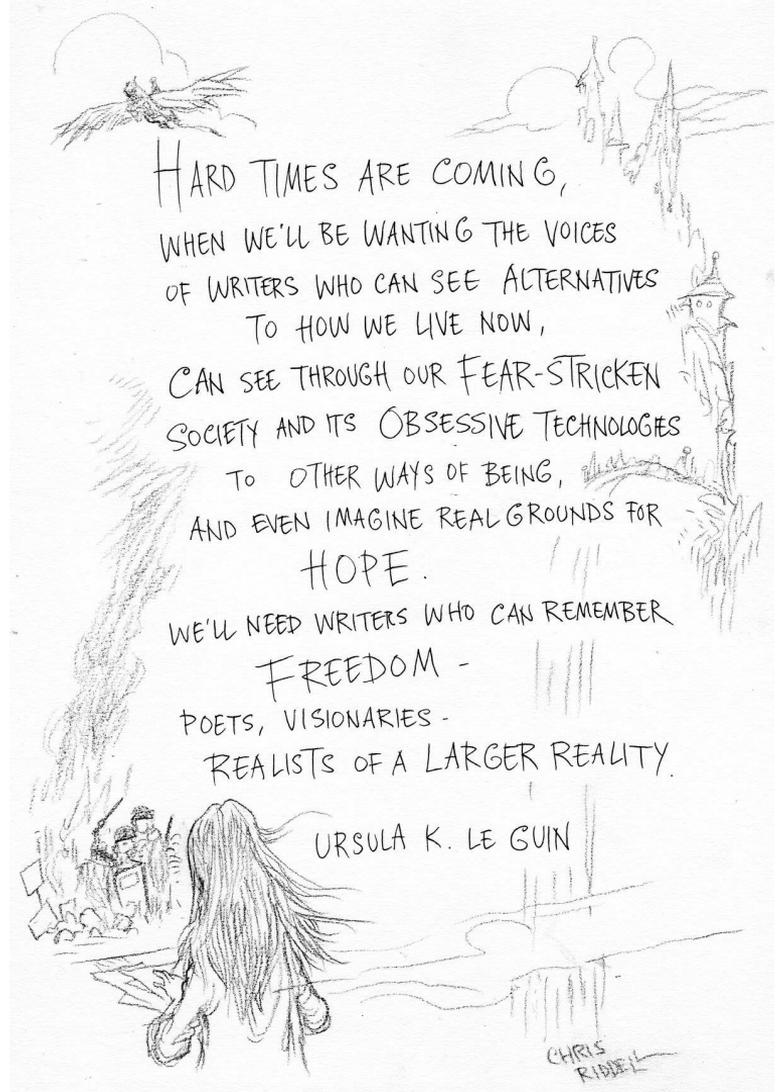


Further reading - if you only read one general book about this:

David Fleming was most certainly one of those authors, and '[Surviving the Future. Culture, Carnival and Capital in the Aftermath of the Market Economy](#)' is most certainly a book worth your time to read! Invercargill Library has a copy in, and it's on Audible too if you prefer to listen. [Review here](#).

“Localisation stands, at best, at the limits of practical possibility, but it has the decisive argument in its favour that there will be no alternative.”

His larger work "[Lean Logic](#)" freely available online.

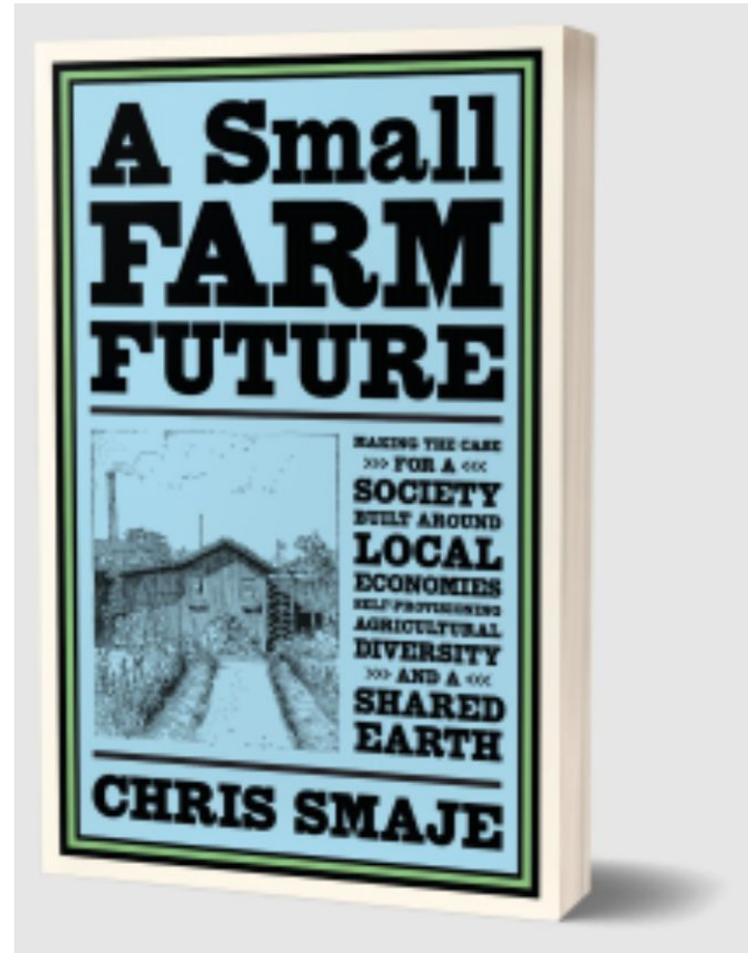


Further reading - a book on farming in an energy constrained future:

Chris Smaje started out as an academic sociologist and anthropologist, and is now a smallholding farmer in the South West of the UK. He has been serialising excerpts of his book, with further commentary on resilience.org:

“A Small Farm Future analyses the complex forces that make societal change inevitable; explains how low-carbon, locally self-reliant, agrarian communities can empower us to successfully confront these changes head on; and explores the pathways for delivering this vision politically”

[Here's a great interview](#) with Chris that gives a good overview in half an hour.



Further Educational Resources:

All the resources below are free full texts available online / as pdf, unless noted:

- Summary article of the issues I've raised giving a narrative perspective on some implications: <http://bit.ly/oilocenedfk> & <http://bit.ly/oilocene>
- Oil Shortages - further references : <http://bit.ly/oilshortage>
- Energy terms explained and linked together: [Energy Primer](#)
- [The Limits to Growth: 50 years on](#) interview - Heinberg & Holmgren
- An overview of how energy fits into other considerations: <https://bit.ly/RBREAD>
- A positive vision of a sustainable future civilisation in 100 years : [Entropia](#)
- Perspectives on China (books to buy):
 - [“The Patterning Instinct”](#) - Jeremy Lent
 - [“The New Silk Roads”](#) - Peter Frankopan
- How Economics Became a Cult: <http://bit.ly/2OUSpkq>
- resilience.org - news aggregation service from the Post Carbon Institute.

**Additional slides
for discussions:**

Think about our relationship to technology

*“We have Paleolithic Emotions, Medieval Institutions, and **God-Like Technology**”*

E.O. Wilson

*"Any sufficiently advanced technology is **indistinguishable from magic**"*

Arthur C. Clarke

*“Dear future generations: Please accept our apologies. **We were rolling drunk on petroleum.**”*

Kurt Vonnegut

<https://bigthink.com/hard-science/eo-wilson-what-makes-us-human-paleolithic-emotions-medieval-institutions-god-like-technology/>

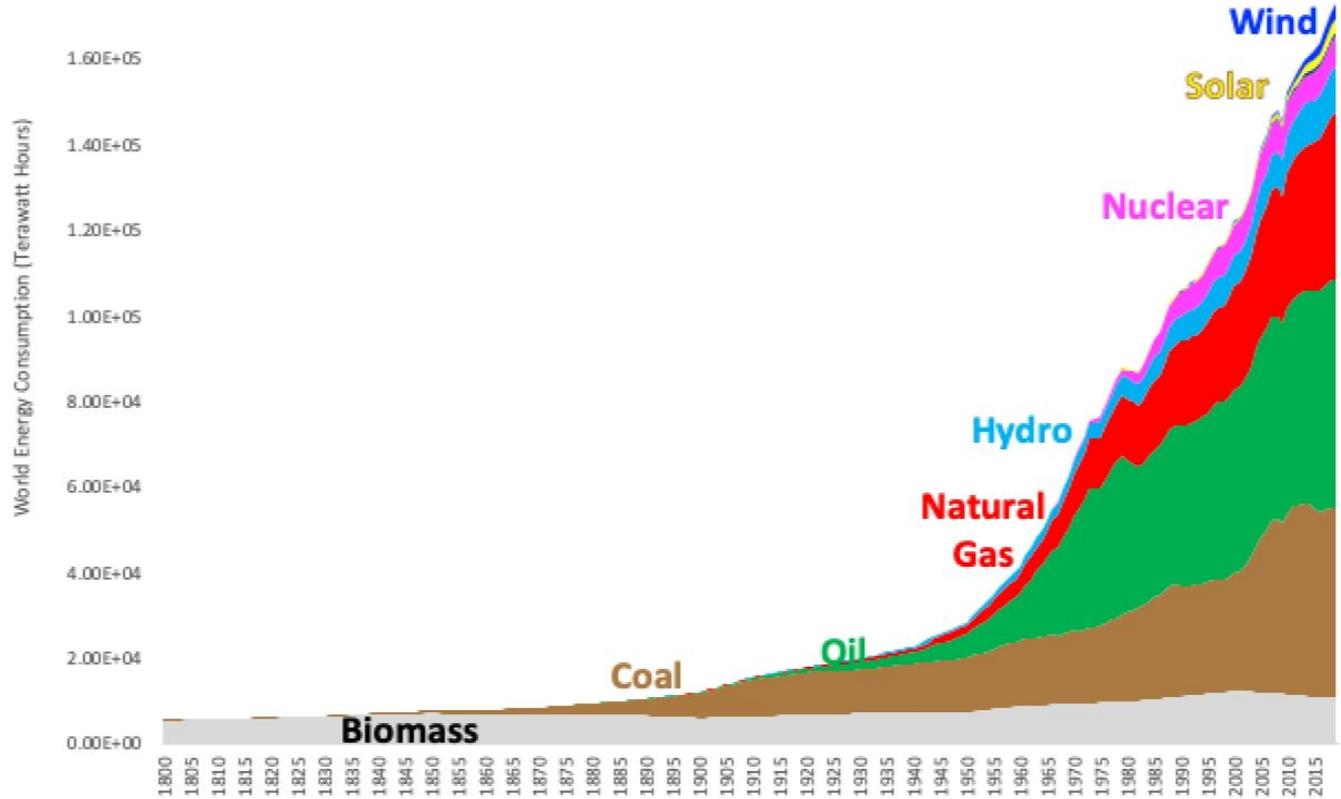
<https://lab.cccb.org/en/arthur-c-clarke-any-sufficiently-advanced-technology-is-indistinguishable-from-magic/>

https://www.goodreads.com/author/quotes/2778055.Kurt_Vonnegut_Jr <https://mahb.stanford.edu/blog/kurt-vonneguts-letter-relevant-today/>

**A question to those who point to
technological progress as a way
out of increasing carbon
emissions:**

If
technology
is going to
reduce our
emissions,
when is it
going to
start..?

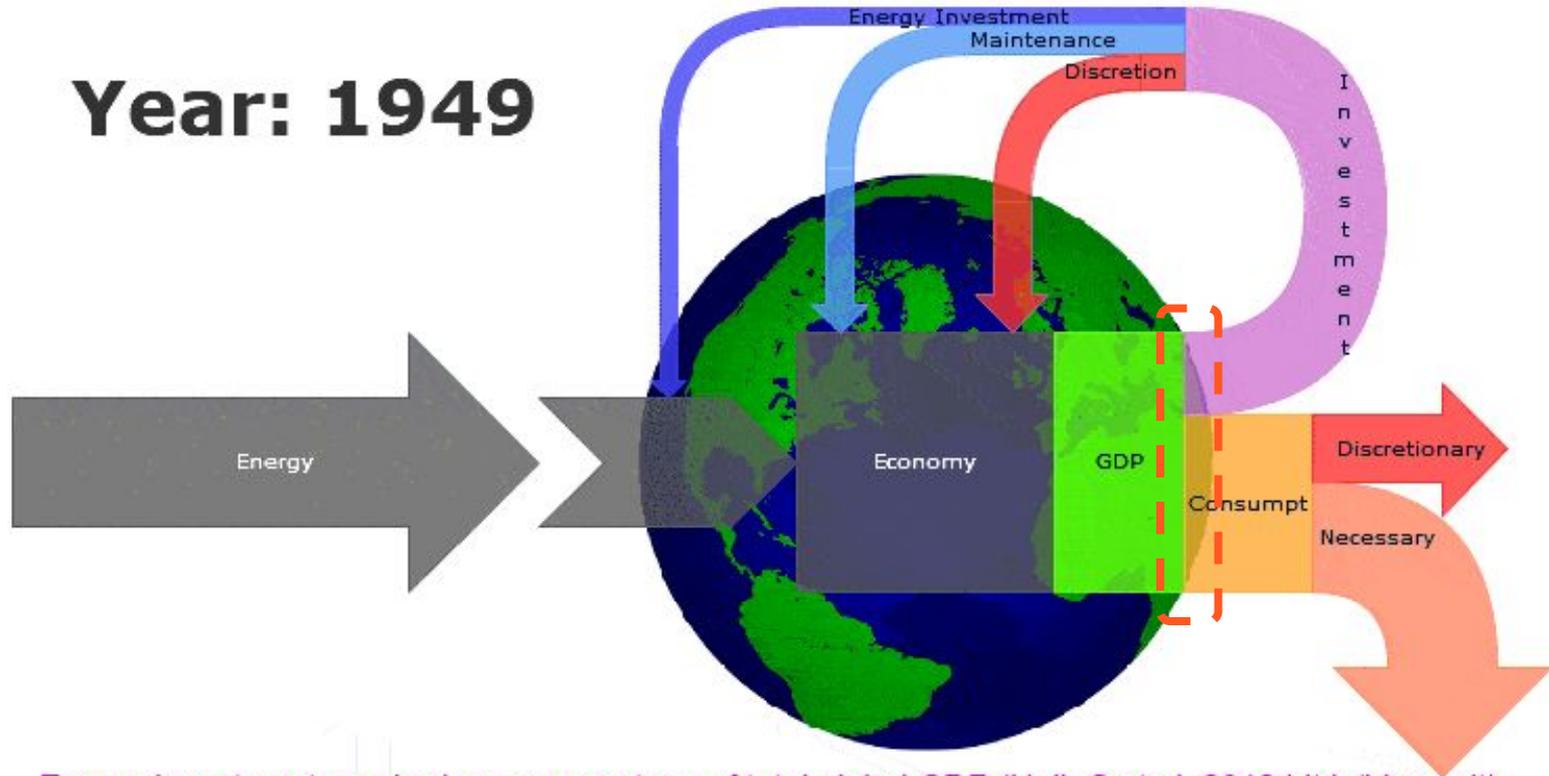
Energy transitions are additive
The relative percent of fuels changes but volumes rarely decrease
The world uses as much biomass today as in 1800



Source: EIA, BP, IEA, FRED, OWWD, World Bank & Labyrinth Consulting Services, Inc
Labyrinth/Climate Change/OWID/ OWID PRIMARY ENERGY CONSUMPTION_global energy substitution

Charles Halls - net energy decreases over time

Year: 1949



Energy investment required as a percentage of total global GDP (Hall, C et al, 2012 bit.ly/hlcsmeit)

Even if we achieve zero growth in energy use, as net energy declines, the amount of energy and money required to obtain energy increases exponentially, and the discretionary money available shrinks accordingly...

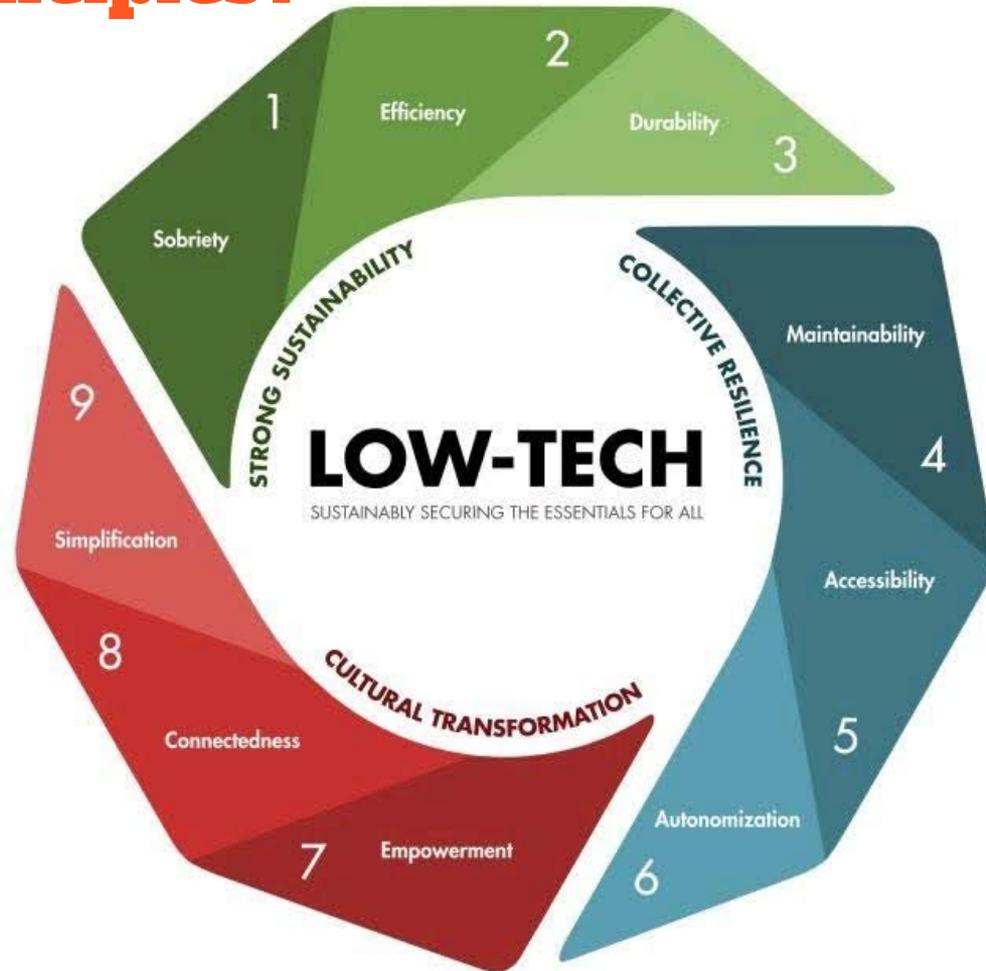
Appropriate Technology

Low Tech Approaches

"[Appropriate technology](#) is a movement encompassing technological choice and application that is small-scale, affordable by locals, decentralized, labor-intensive, energy-efficient, environmentally sustainable, and locally autonomous."

Interesting possibilities arise when you combine old technology with new knowledge and new materials, or when you apply old concepts and traditional knowledge to modern technology. There are many [low tech options](#) to explore!

Guiding principles?



- 1 Sobriety
- 2 Efficiency
- 3 Sustainability
- 4 Maintainability
- 5 Accessibility
- 6 Autonomisation
- 7 Empowerment
- 8 Connectedness
- 9 Simplification

What about environmental concerns?

- The reality is that the economic system *is embodied and embedded* in the material world.
- Economists describe disruptive impacts of economic activity as “externalities”
- Ecological disruption is the result of industrial economic activity and is ubiquitous.
- The scale of these impacts are now a threat to life on the planet.

As such...

I'm not at all saying I support the oil industry - it has deliberately led us down this dead end path to support growth in oil supply, and denied the impacts it is creating consistently for over half a century.

For more on this:

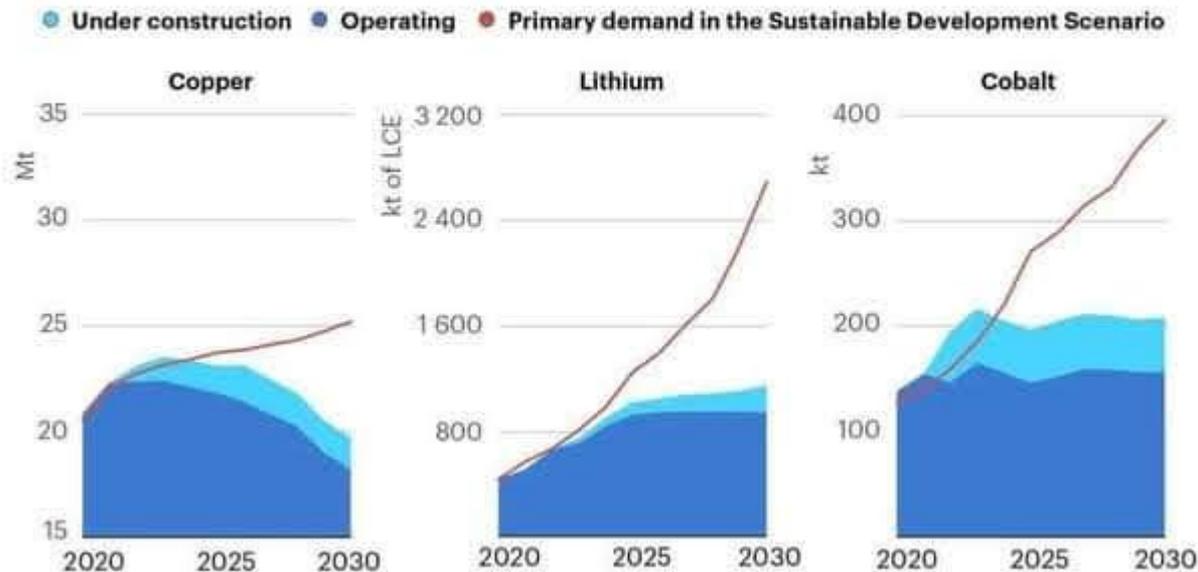
[Big Oil v the World Series 1 1. Denial BBC Documentary 2022](#)

[More than 6 billion people will be increasingly exposed to extremes under global warming](#)

However we need to examine the risks of our strategic dependence from a resource depletion perspective.

A little more on minerals

Committed mine production & primary demand for selected minerals in the Sustainable Development Scenario



International Energy Agency

[More on this from Simon Michaux](#)

wiseresponse.org.nz/2021/08/31/seminar-are-there-biophysical-limits-to-growth/

Also bit.ly/titowaup

Oil from a Critical Raw Material Perspective 2019

1 hour video – overview of the report The Mining of Minerals and the Limits to Growth 2021

15 min video – summary of the report Assessment of the Extra Capacity Required of Alternative Energy Electrical Power Systems to Completely Replace Fossil Fuels 2021

45 min interview – summary of the report and implications

A little more on minerals



**The Energy Transition Delusion:
Inescapable Mineral Realities**

Mark Mills
Energy Expert and Senior Fellow,
Manhattan Institute

SKAGEN FUNDS'
**NEW YEAR'S
CONFERENCE**
WEDNESDAY FEBRUARY 2023

[Mark Mills:
The energy transition
delusion:
inescapable mineral realities](#)

Even for those who are still in denial about the energy supply situation (like Mark), it's clear the mineral supply situation is a huge barrier to green growth and the energy transition as currently envisaged!

Section 2 - Transportation in Aotearoa implications

- The fundamental question that all the above brings me to personally when considering DEG: ‘What can we sustain locally, given that highly efficient, complex, lean global supply chains are faltering before our eyes?’
- My assumptions informed by this perspective are that we:
 - Can’t rely on complicated industrial technologies to be affordable / available going forwards.
 - Can use whatever adaptive capacity we have left to adapt existing or put in place systems that will ‘degrade gracefully’...

Section 2 - DEG options based on our new perspective!

We're excluding exotic or thermodynamically insane future technologies such as hydrogen, SMR's, [big improvements in battery tech](#), zero point energy, etc. We don't have the time to wait for them, if they could ever exist at a useful scale.

Available in the market, with service and backup for O&M in place:

- Solar PV and Thermal for [residential](#) and commercial / [industrial](#) applications.
- Hydro - Micro and Macro scale systems including [direct power](#).
- [Wind](#) including for direct power and [heating](#), but [with serious limitations](#).
- Biomass Thermal Energy inc. gasifying log boilers, external combustion engines and retrofit gasifiers for internal combustion engines.

**Percentage growth rates
are exponential**



Relevant section for this presentation is 17:16 to 18:03, [available as a discrete clip here.](#)

The rule of 70

A sustained percentage growth rate eventually leads to a doubling of whatever is growing.

To find out how quickly this will happen, a 'rule of thumb' is to divide the percentage growth figure into 70.

The rule of 70

The rough time in years for something to double:

- 2% growth: $70/2 = 35$ years to double.
- 3.5% growth: $70/3.5 = 20$ years to double.
- 7% growth: $70/7 = 10$ years to double.
- 10% growth: $70/10 = 7$ years to double.

Net Energy - an overview

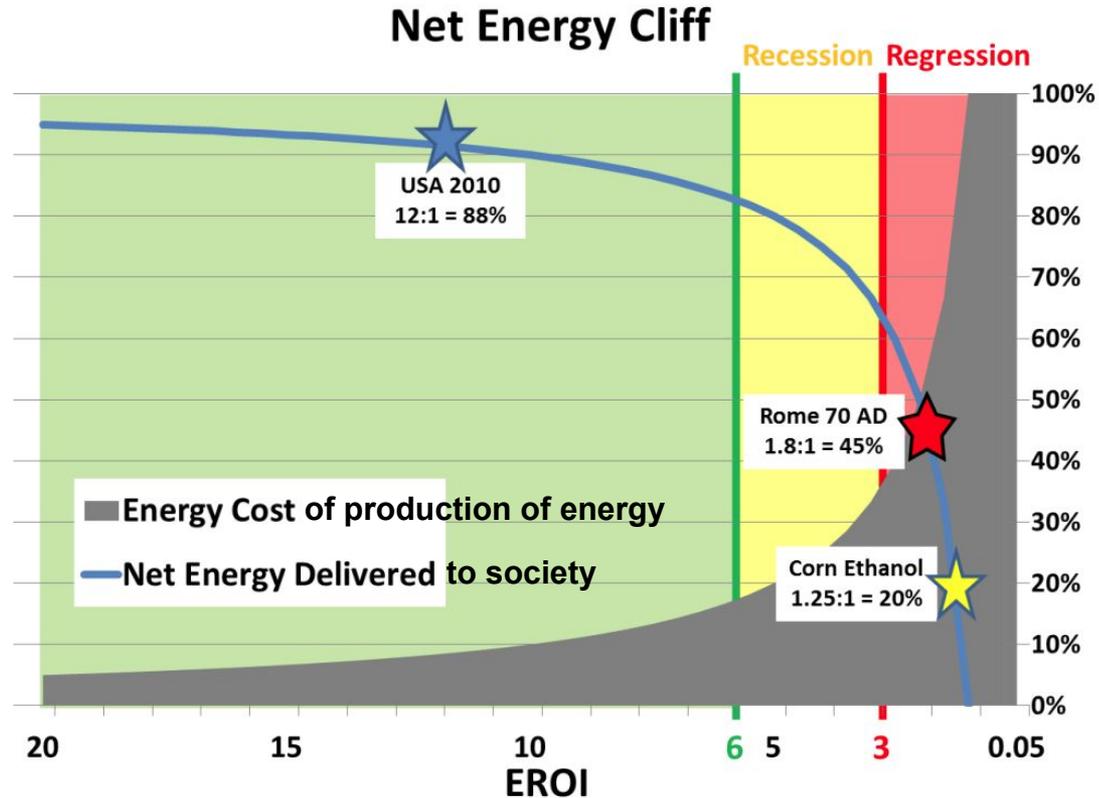
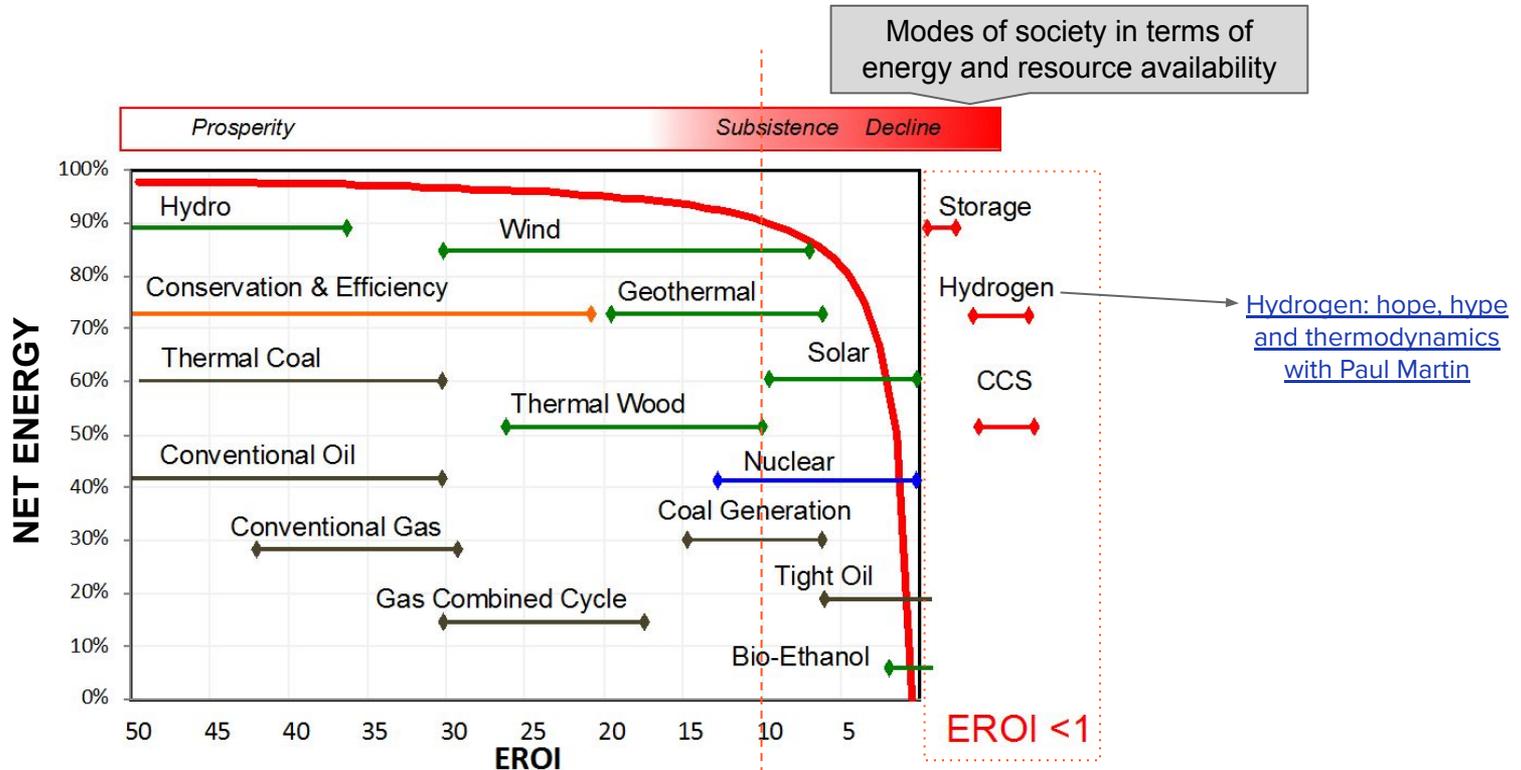


Figure 2. Net Energy Cliff

Net energy performance of DER's

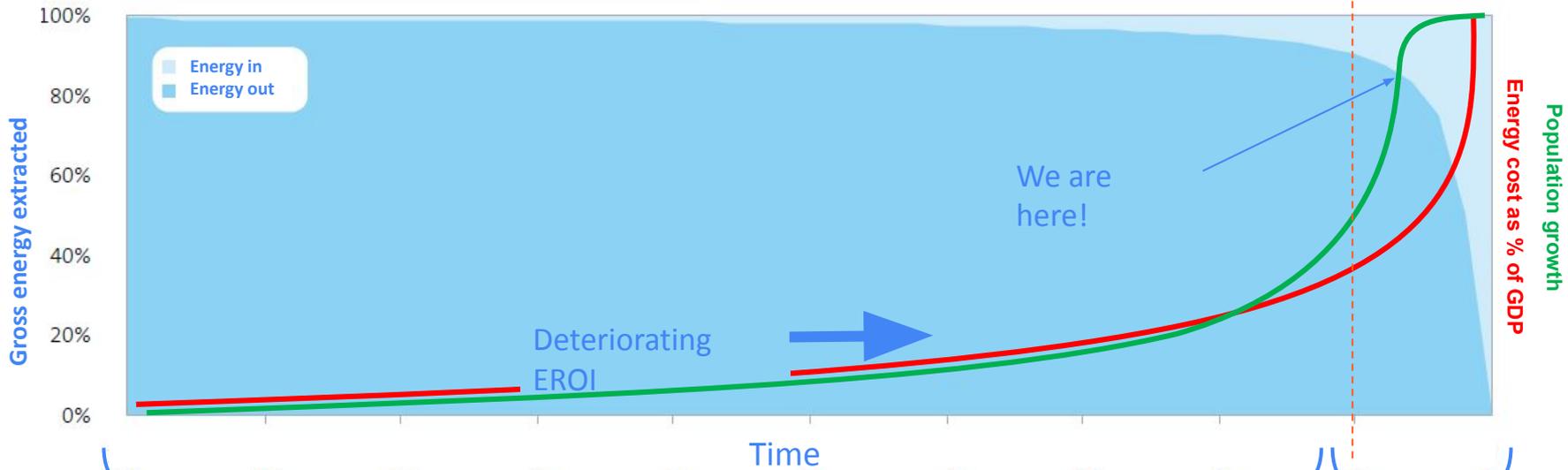


Beyond this 'threshold', the net energy reduction means that modern industrial society is increasingly less viable.

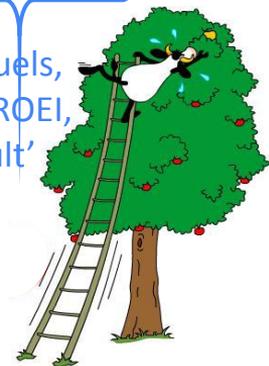


[Is there such a thing as a "net energy cliff"? | BiophysEco](#)

<https://duckduckgo.com/?q=net+energy+cliff>



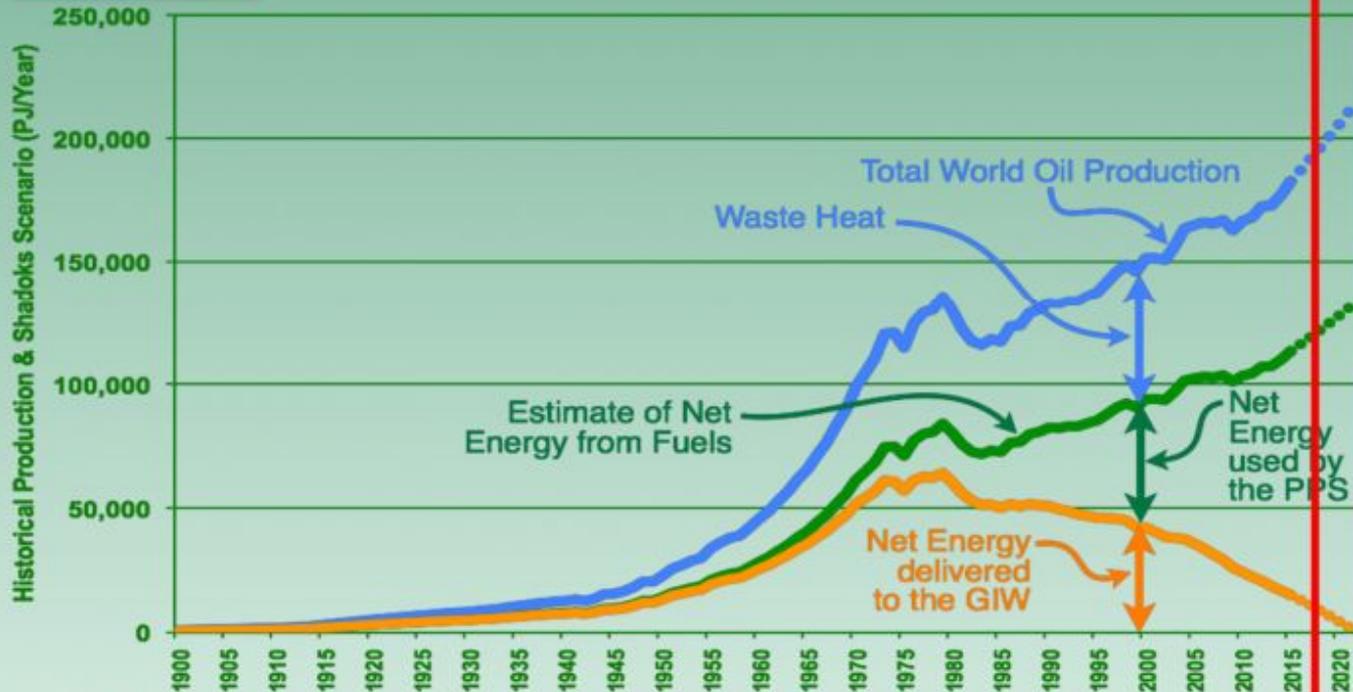
50% Fuels,
High EROEI,
'low-hanging'



50% Fuels,
Low EROEI,
'difficult'



The Oil Age... as we knew it



Unless alternative primary energy sources are brought in rapidly enough the Oil Age as we know it will have fizzled out by circa 2022

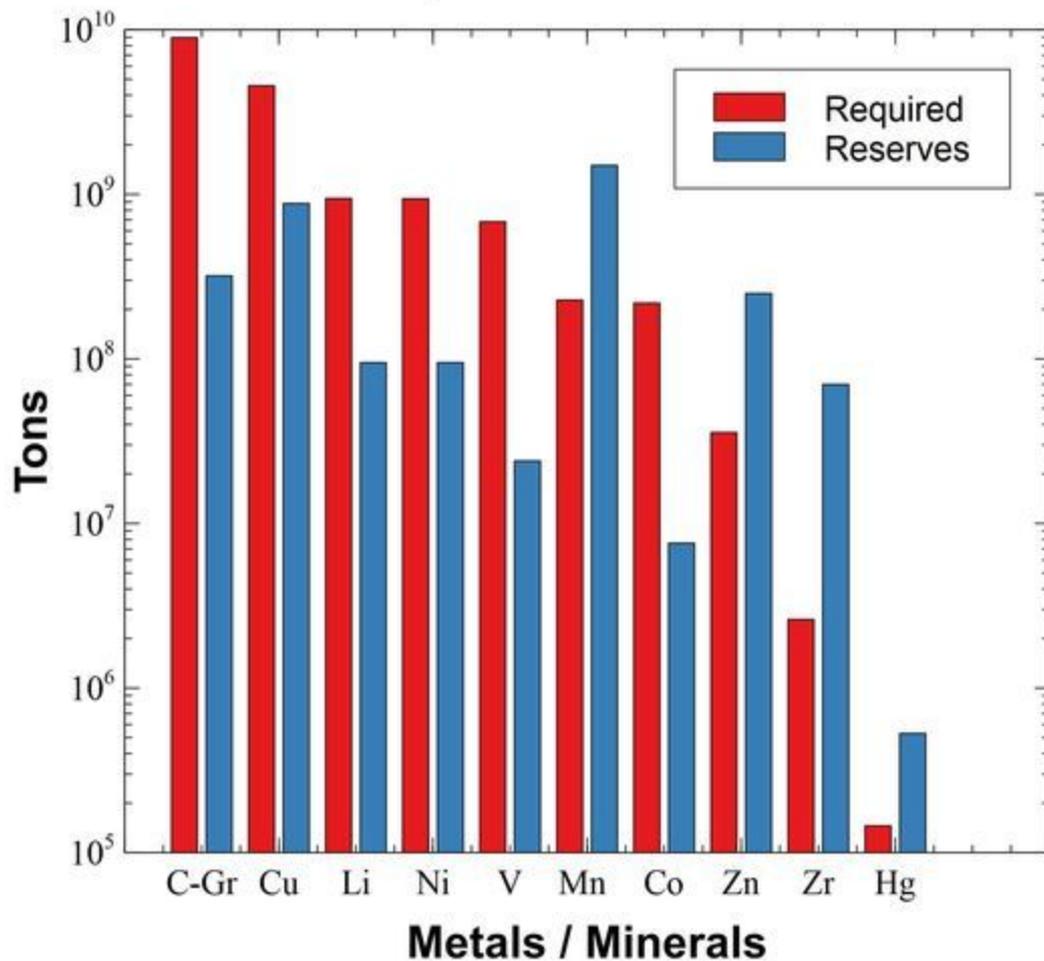


Our future 'Solution Spaces' are constrained by:

- COVID and related(?) governmental response.
- Ecological crises and Planetary Boundaries.
- Global Financial Crisis – Liquidity Crunch and Economic Depression.
- The Psychological Driver of Deflation and the Collapse of the Trust Horizon.
- Instability and the 'Discount Rate'.
- Energy – Demand Collapse Followed by Supply Collapse.
- Declining Energy Profit Ratio and therefore Socio-Economic Complexity.
- Blind Alleys and Techno-Fantasies.
- Geopolitical Turmoil...

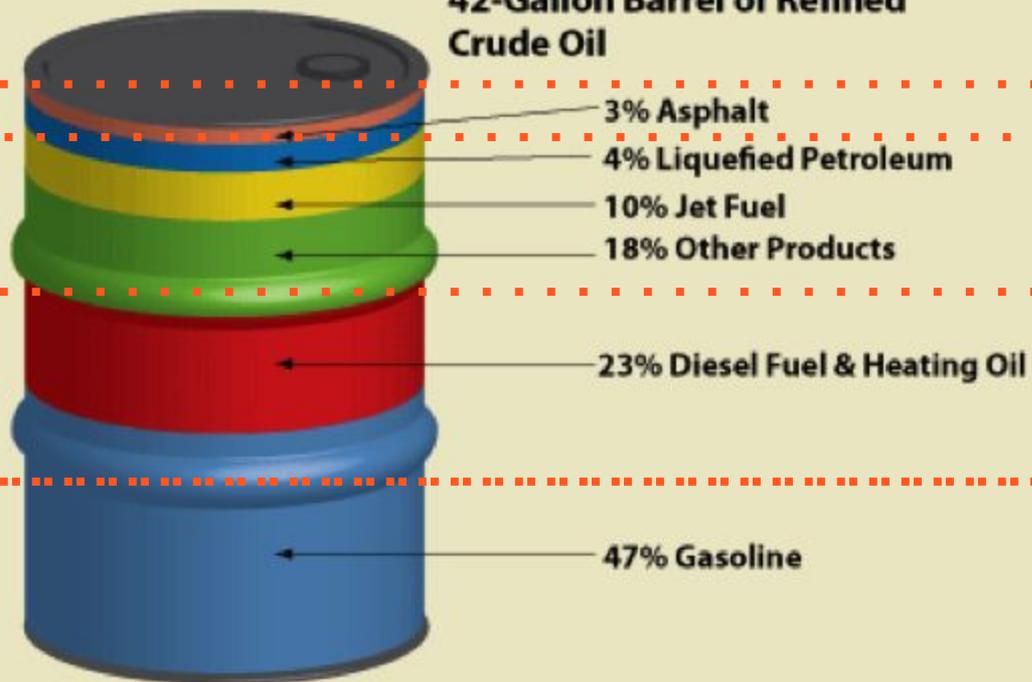
Leads to

Renewables Requirements and Reserves



Products Made from a Barrel of Crude Oil

Typical Products Made from a 42-Gallon Barrel of Refined Crude Oil



Source: U.S. Department of Energy.

Green Growth vs Degrowth

A developing national discussion.

The basic point of contention is does the Green Growth narrative:

- Reduce environmental impact?
- Do anything at all to address the net energy situation?
- Actually understand the quantity of energy and resources that a renewable energy transition that supports anything like the modern globalised industrial economy would require?

The answer appears to be no to all three questions, so the alternative must therefore be targeted degrowth to a future steady state within planetary limits.

But importantly is also wrong on the downside in its long term demand assumptions

Figure 3.16 ▸ Global supply outlook from selected sources in the New Policies Scenario

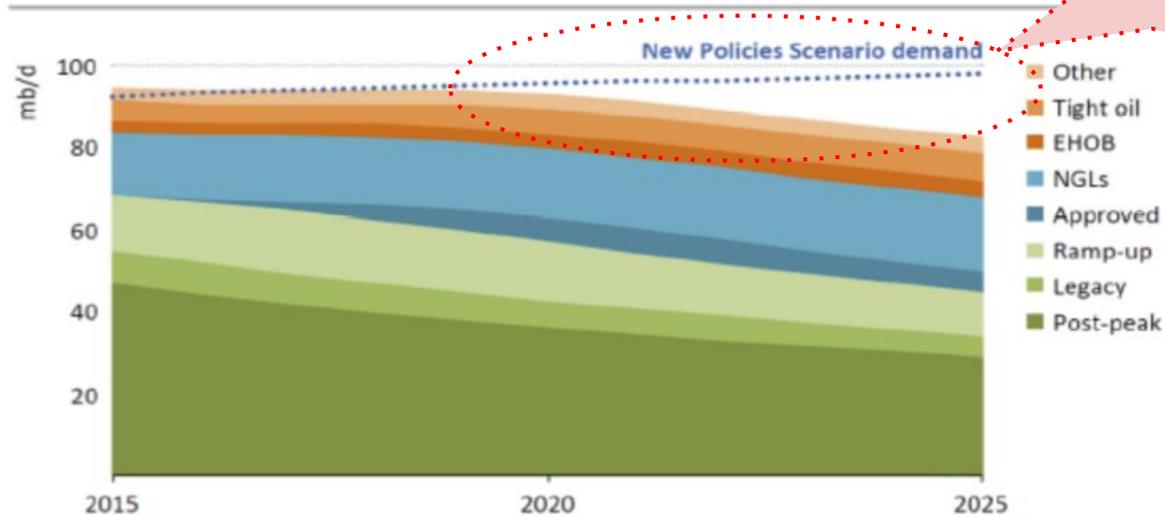


Chart shows demand forecast vs actual oil supply forecasts

A supply-demand gap emerges that must be filled by production from conventional crude oil projects yet-to-be-approved

In doing so, our energy story has shaky foundations...

“The energy trilemma

Greenhouse gas emissions – the need to electrify.

*We **expect** to build xx TWh of electricity generation by 2050, growth + retirements + decarbonization*

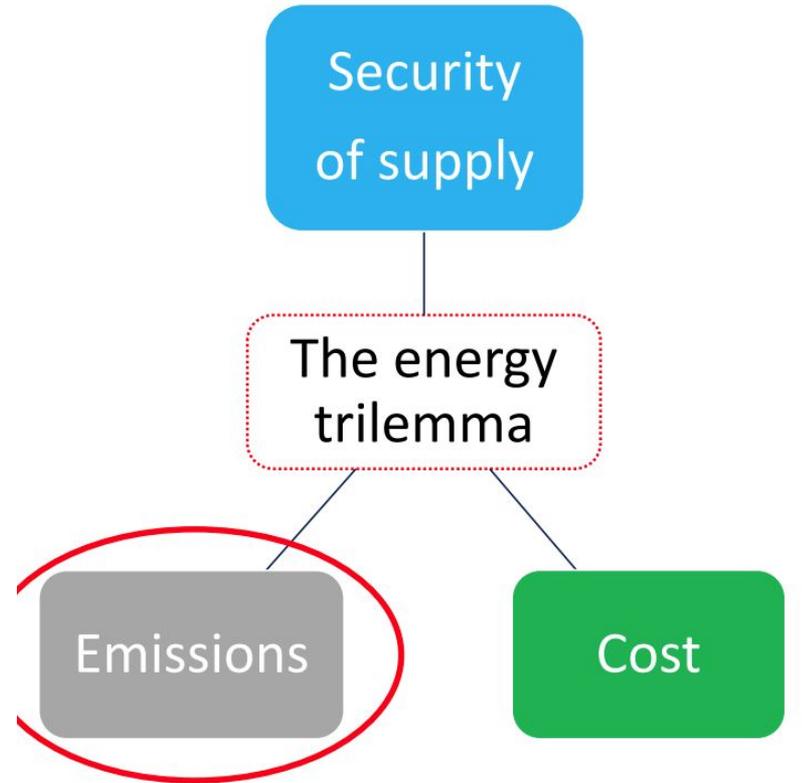
***Demand growth** over the next few decades, but highly uncertain.*

*What ~~shall~~ we build and how much might it cost? **can / should??***

Predicted future electricity supply.”

Because it needs to be attractive to investors!

[\(Click for Meridian's 2021 investor presentations\)](#)



Transportation in Aotearoa implications

- We're an Island in an 'expanding ocean' - future mobility will be limited by energy.
- Increased air fares and fuel price volatility are the warning signs.
- Starting with longer term trends first, it's clear that we'll end up in a post-industrial future at some point.
- In the medium term, increasing cost of capital projects and operational / maintenance costs will trend strongly up, leaving us with very stark choices.
- In the short term, if we chose to head in the direction indicated by the net energy lens, then we would save society much time and wasted resource.
- *What are we waiting for?*

What this looks like in practice

- Negawatts! We have plenty of cost effective options to **reduce demand through integrated planning processes.**
- Our current energy system will become increasingly less viable over time.
- We will have to triage the infrastructure we have, and abandon bits that are no longer viable over time.
- The periphery will be affected first, as acknowledged by Southland lines company Powernet's investigations into DER, driven by the acknowledged expense of maintaining cables for many km's to serve a single dwelling or farm.
- Solutions that rely on large quantities of high tech equipment are likely to become unaffordable and or unavailable, and therefore impossible to maintain.

Transition Engineering - a new perspective

If we're to get better outcomes, we need better processes.

Transition Engineering's InTIME process looks 100 years into the future and 'back-casts' from there to determine the steps required.

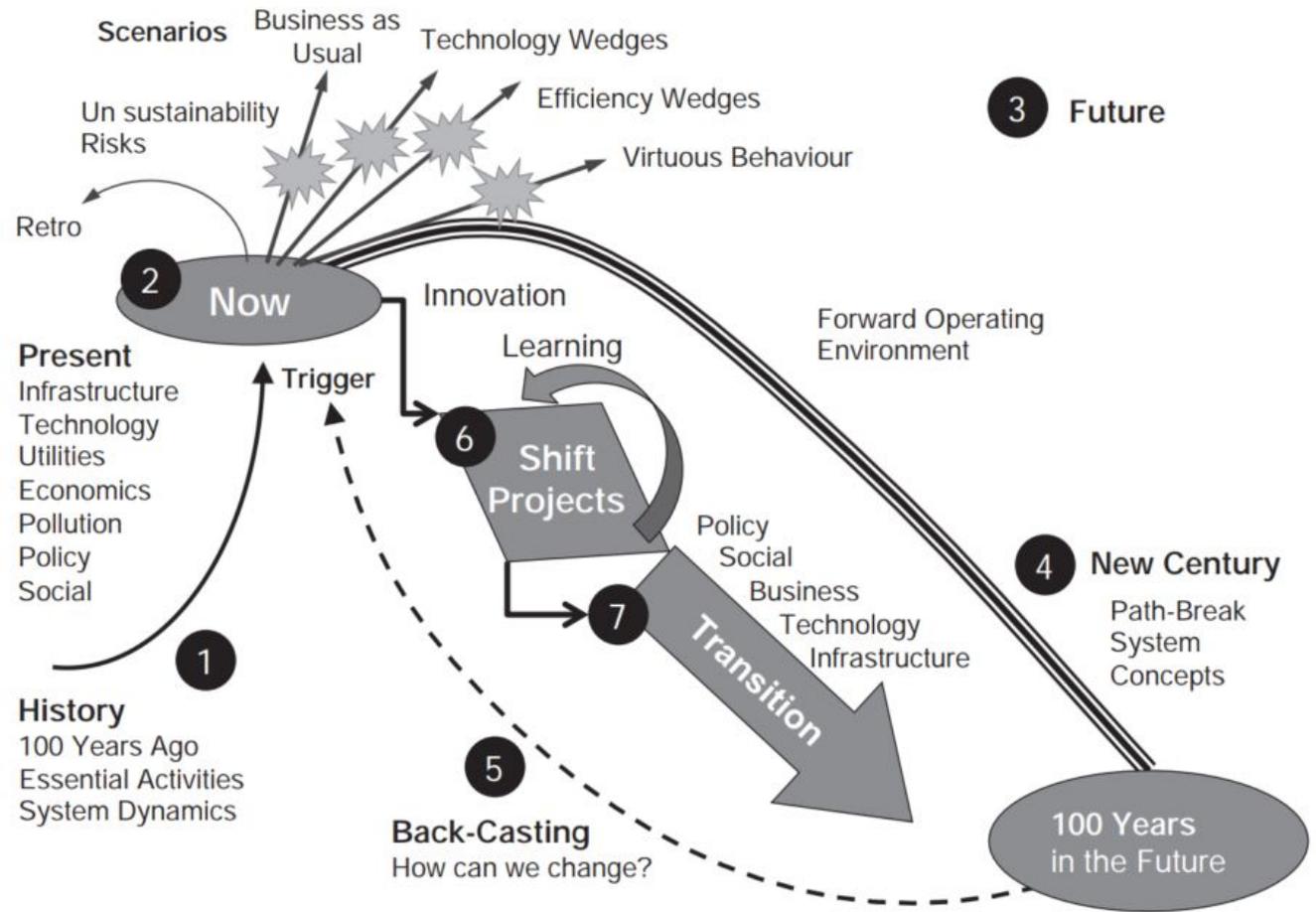
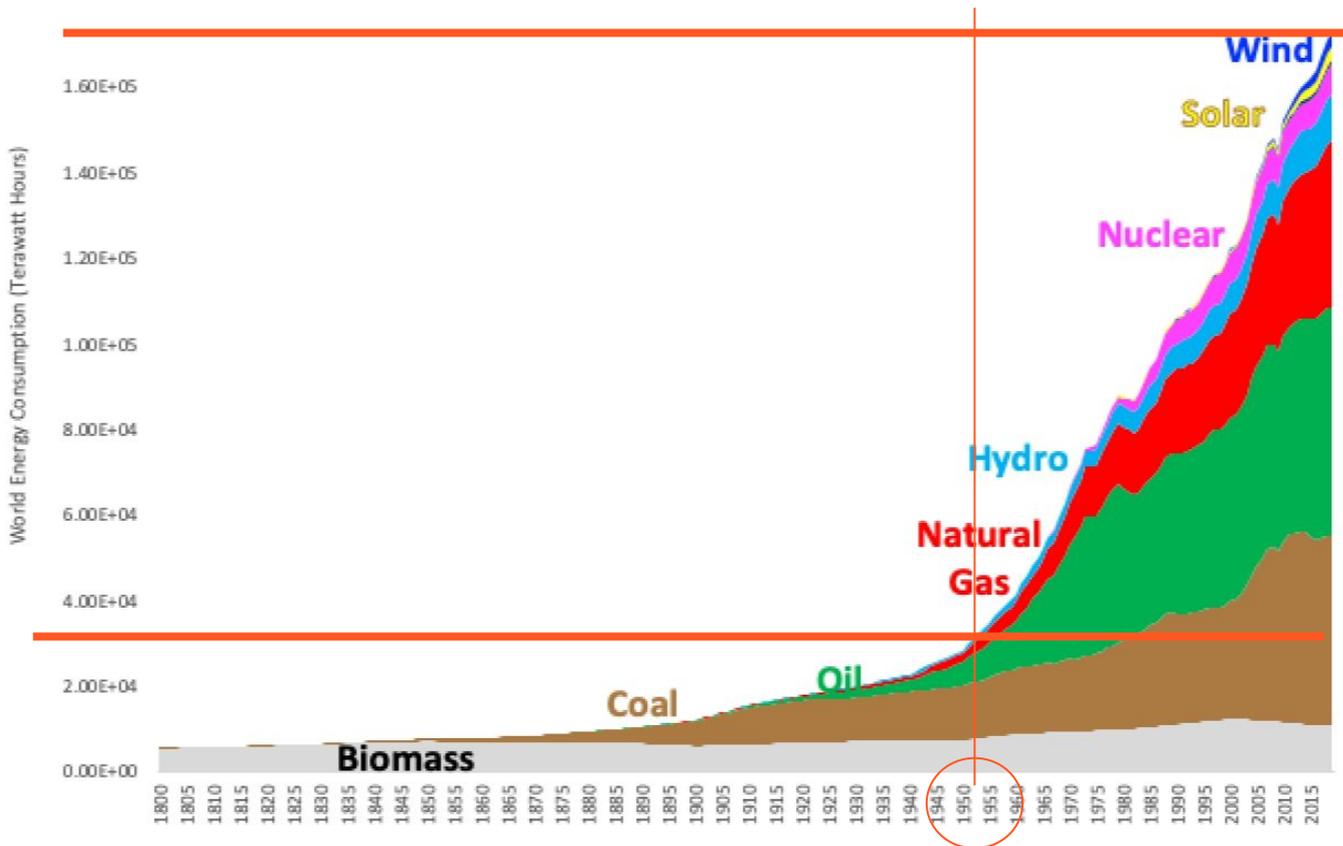


FIGURE 4.1 Interdisciplinary transition innovation, management and engineering (InTIME) approach framework.

Is a 1950's level of energy expenditure really that unpalatable?

Energy transitions are additive
The relative percent of fuels changes but volumes rarely decrease
The world uses as much biomass today as in 1800



Source: EIA, BP, IEA, FRED, OWWD, World Bank & Labyrinth Consulting Services, Inc
Labyrinth/Climate Change/OWID/ OWID PRIMARY ENERGY CONSUMPTION_global energy substitution